EXECUTIVE SUMMARY

The Pipe Creek-Little Pipe Creek Diagnostic Study provides a thorough review of a small portion of Pipe Creek and three of its tributaries. In 2001, the Howard, Miami, and Grant Soil and Water Conservation Districts (SWCDs) applied for an Indiana Department of Natural Resources (IDNR) Lake and River Enhancement (LARE) grant to fund this diagnostic study. This study includes historical and existing information (such as land use, soils, agriculture trends, climate, etc.) as well as results from habitat assessments and water quality tests.

As a cost-savings measure, the SWCDs requested that the majority of the study be done in-house by Conservation Partnership Staff. However, it was decided that the SWCDs should hire a qualified consultant to complete the water quality testing as the current staff did not possess the expertise to meet the LARE program's Quality Assurance and Control criteria. The SWCDs selected Greg Bright of Commonwealth Biomonitoring to conduct the habitat assessment and water quality sampling needed to complete this study.

The subwatersheds targeted in this study are part of the Wabash River Drainage Basin and consist of 40,088 acres within the boundaries of Howard, Grant, and Miami Counties (Figure 1). Over ninety-six percent of the subwatersheds are in agricultural row crops. Approximately 187 acres of specialty crops (i.e. tomatoes) are grown in the watershed. There are six confined animal feeding operations scattered throughout the study area. Less than one percent of the land is designated as urban. The major soil type in all four subwatersheds is Blount, a deep poorly drained soil that necessitates tile drainage for crop production. Approximately three percent of the entire study area is classified as Highly Erodible Land (HEL). The Converse Wastewater Treatment Plant is the only permitted discharger in the subwatersheds.

Water quality samples were taken two times, once during base flow conditions (October 2002) and once during storm flow conditions (May 2003). Samples taken during base flow conditions indicated that most parameters, with the exception of Dissolved Oxygen (D.O.) and Chlorophyll A (ChlA), fell within acceptable ranges for most forms of aquatic life. Nutrient values were relatively low at all sites and none of the sites exceeded the Indiana water quality standard for *E. coli*. Storm flow samples portrayed a much different picture of water quality. *E. coli* levels exceeded that state standard at every site. State surface water standards for turbidity were also exceeded at every sampling site. Nutrient levels were much higher during storm flow conditions than they were during base flow conditions.

Results from the Hilsenhoff Macroinvertebrate Biotic Index indicate that every site has some level of organic pollution. Using the Qualitative Habitat Evaluation Index, it was found that seven of the nine sites had optimal habitat for aquatic life. During storm flow sampling, biotic index values were significantly greater than the habitat values at several sites (Little Pipe Creek and lower Honey Creek), indicating there are excessive nutrient inputs to these waterbodies (Bright, 2003).

Various Best Management Practices (BMPs) are recommended to reduce sediment and nutrient inputs. Some of these practices include, but are not limited to, the following practices: conservation tillage, filter strips, grade stabilization structures, nutrient management, and tree

plantings. It is necessary to increase the stakeholders' knowledge of the water quality concerns in their watersheds to increase their willingness to install BMPs. It is also recommended that the SWCDs engage in an educational campaign to inform landowners how to take proper care of their septic systems in an effort to reduce *E. coli* levels.

ACKNOWLEDGEMENTS

This watershed study was completed with financial assistance from the Indiana Department of Natural Resources (IDNR) Division of Soil Conservation (DSC) and the Grant, Howard, and Miami County Soil and Water Conservation Districts. Current water quality conditions were documented with stream sampling performed by Greg Bright of Commonwealth Biomonitoring. Stream sampling included analysis of chemical parameters, aquatic habitats, and macroinvertebrate populations. Historical and existing data were collected and documented by: Kelley Barkell, Ted McCammon, and Gail Peas, Resource Specialists with the IDNR DSC; Sarah Garrison, Howard County Soil and Water Conservation District (SWCD) Watershed Resource Technician, and Ronald Hellmich, IDNR Division of Nature Preserves. Other contributors to this study included: Kerry Smith, United States Department of Agriculture (USDA) Natural Resources Conservation Service; Daniel Bruggener and Stacie Tucker with the Indiana Department of Environmental Management (IDEM); Alice Quinn with the Grant County Health Department; Ken Scott with the Miami County Health Department; Greg Lake with the Howard County Health Department and Bud Cartwright with the Converse Wastewater Treatment Plant. Letters of support were received from: Paul Raver, Howard County Commissioner; Craig Boyer, Miami County Commissioner; Ron Newhouse and Roger Johnson, landowners farming in the watershed. Jennifer Bratthauar, IDNR DSC Agriculture Conservation Specialist, compiled all of the research into the final report. Jill Hoffman, IDNR DSC Aquatic Biologist, provided Arcview data layers and much needed guidance from the beginning of the study to the very end.

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INTRODUCTION

The Potter's Ditch, Honey Creek, Sugar Creek, and Little Pipe Creek watersheds make up the northeast corner of Howard County, southern Miami County, and the northwest corner and west central portion of Grant County (Figure 1). The watersheds are part of the Wabash River Drainage Basin. According to the Grant, Howard, and Miami County Soil Surveys, the area is, on average, located 820 feet above sea level. This area was shaped by glaciers resulting in an upland till plain area that is part of the Central Till Plains. The area is nearly level with the majority of the changes in relief occurring near the creek beds. The soils in this area consist of clay soils that are subject to compaction. The soils have poor drainage and are subject to frequent ponding. The area originally consisted of swamps and marshes with few natural drainage ways. An extensive network of open drainage ditches and underground tiles have been constructed which allows approximately 96% of the area to be farmed. Ground water storage is abundant in this area due to underground glacial deposits that have filled in ancient streambeds.

Sugar Creek flows into Honey Creek approximately one mile southwest of the town of Amboy. Honey Creek then flows northeast through Amboy and begins to flow almost directly north into Pipe Creek, which then flows into the Wabash River. The headwaters of Sugar Creek and Honey Creek originate in Howard County. Little Pipe Creek's headwaters originate in Grant County, southeast of the town of Sims and then flows north through the town of Converse into Pipe Creek (Figure 2). The Little Pipe Creek subwatershed makes up the largest acreage in the study area (Table 1). Potter's Ditch originates in Grant County and flows west to Pipe Creek. Potter's Ditch subwatershed also includes land to the north of Pipe Creek that flows directly into Pipe Creek.

TABLE 1
Pipe Creek Subwatershed Acreages

Subwatershed	Acres
Pipe Creek-Potter's Ditch	8,919.20
Sugar Creek	8,272.80
Honey Creek	9,248.30
Little Pipe Creek	13,647.70
Total	**40,088**

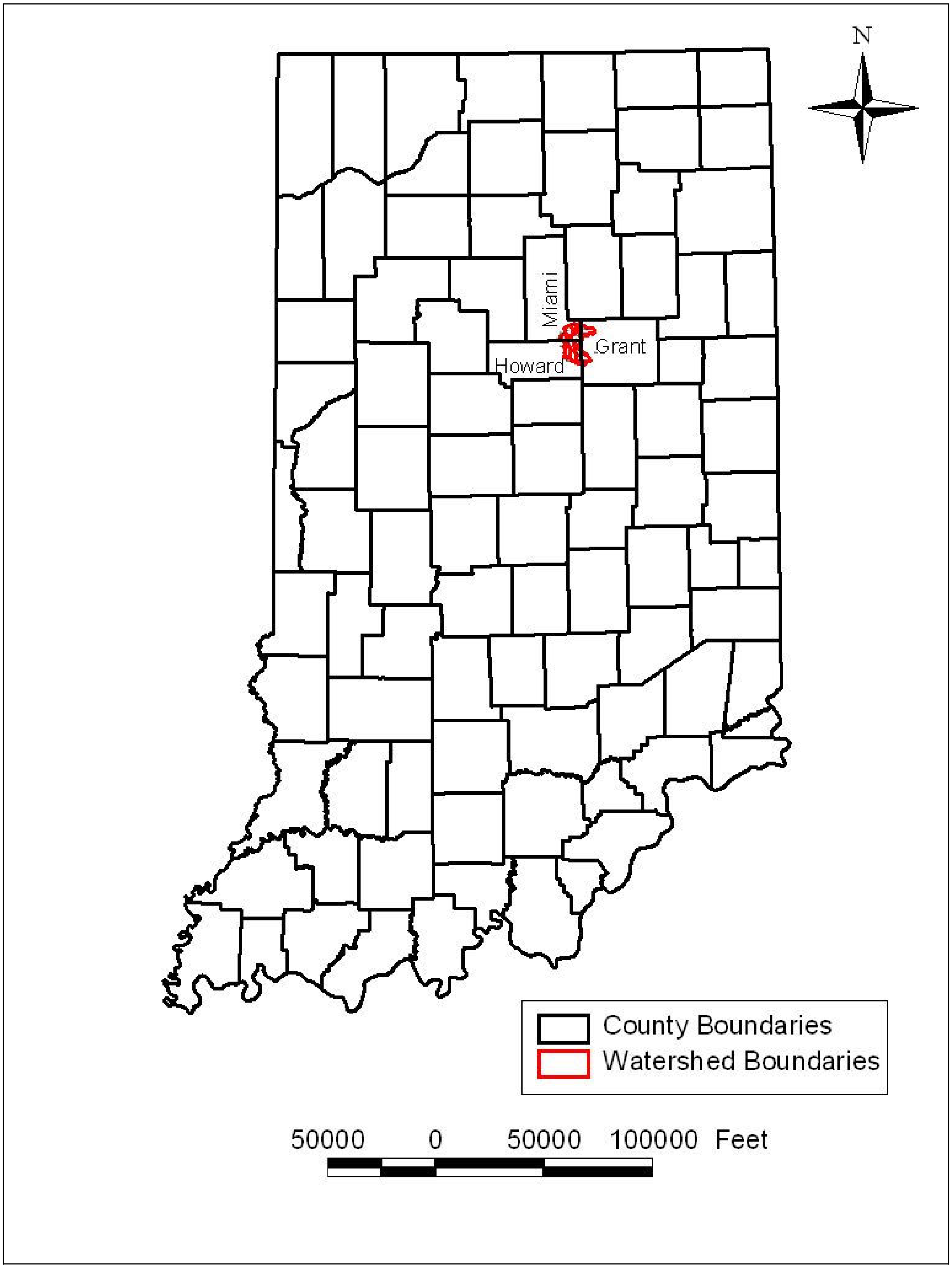

Figure 1. Indiana State Map with Diagnostic Study Subwatersheds

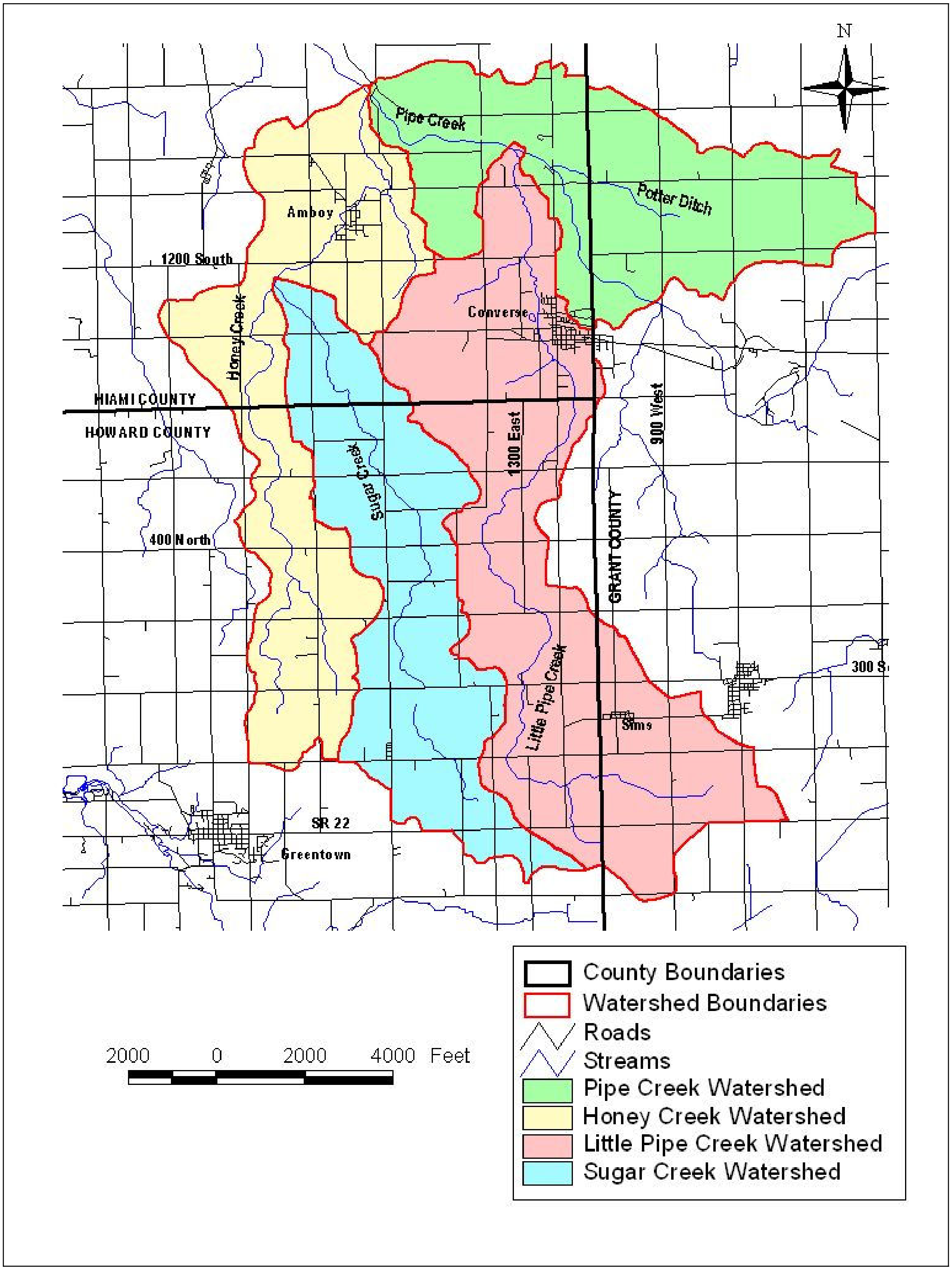

Figure 2. Study subwatersheds

HISTORICAL AND EXISTING INFORMATION

CLIMATE

According to the Grant, Howard, and Miami County Soil Surveys and the Purdue Department of Agronomy, the three counties have a temperate climate. The average temperature is 27 degrees Fahrenheit in the winter and 70 degrees Fahrenheit in the summer. Low-pressure and high-pressure fronts pass through the area frequently. Precipitation averages around 37 inches per year with approximately 29 inches from snow. 60% of the precipitation falls from April to September, with June being the wettest month. The precipitation in the area is typically adequate for crop growth such as corn, fall wheat, spring oats, and soybeans. There are periods with low rainfall in the summer that can cause a mild drought-like condition. It is estimated that 1/3 of the total precipitation enters the open waters of the area and flows out of the county. Relative humidity in the region can vary from 45% to 100% with an average of 65%. Most of the prevailing winds are from the southwest, except in the winter, when winds come out of the north. The average wind velocity is 12 miles per hour. Severe thunderstorms and tornadoes have the potential to occur in the area and may cause localized damage.

TABLE 2
Monthly Average Rainfall for the Cities of Kokomo (Howard Co.) and Marion (Grant Co.)

Month	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
Inches	2.72	2.15	3.20	3.75	3.84	3.58	4.26	3.66	2.98	2.79	3.26	3.16	38.73

TABLE 3
Monthly Average Temperature for the Cities of Kokomo and Marion

Month	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
Degrees Fahrenheit	22.6	25.7	37.5	49.1	60.0	69.6	73.2	70.8	64.6	52.5	41.1	28.6	49.6

Source: Indiana Climate Page, 2002

Averages are based on available weather observations taken during the years of 1961-1990. No information was available for Miami County.

DEMOGRAPHICS AND DEVELOPMENT TRENDS

In 1990, Howard County had an estimated population of 80,827. In 2000, the population had increased by 5.1% to 84,964. The population of Howard County is projected to reach 86,450 by the year 2020, a 1.7% population growth over 20 years. This increase in population growth is most likely going to be in and around the city of Kokomo. It is not representative of population growth throughout the subwatersheds. Howard County had a labor force of 41,400 and an unemployment rate of 5.9% as of December 2001. The median household income in 1998 was $45,037 and the per capita personal income in 1999 was $27,623.

Grant County had an estimated population of 74,169 in 1990. The population had decreased by 1.0% to 73,403 in 2000. The population of Grant County is projected to decline to 72,257 by the year 2020, a 1.5% population decline over 10 years. Grant County has a labor force of 31,930 and an unemployment rate of 7.5% as of December 2001. The median household income in 1998 was $35,355 and the per capita personal income in 1999 was $22,247 (1999).

In 1990, Miami County had an estimated population of 36,897. In 2000, the population had decreased by 2.2% to 36,082. The population of Miami County is projected to reach 38,203 by the year 2020, a 5.5% population growth over 20 years. Miami County had a labor force of 15,950 and an unemployment rate of 6.4% as of December 2001. The median household income was $36,920 in 1998 and the per capita personal income was $20,718 in 1999.

Sources: US Census Bureau; U.S. Bureau of Economic Analysis; Indiana Family Social Services Administration; Indiana Department of Education; Indiana Department of Workforce Development and www.stats.indiana.edu/

TABLE 4
Population Over Time

Year	Howard	Miami	Grant
Yesterday (1990)	80,827	36,897	74,169
Today (2000)	84,964	36,082	73,403
Tomorrow (2020 proj.)	86,450	38,203	72,257
Percent change 1990 to 2000	5.10%	-2.20%	-1.00%

(Source: STATS Indiana, 2002)

SOILS

The soils in these subwatersheds can be categorized into four major soil associations: Blount-Pewamo, Gessie-Shoals, Glynwood-Pewamo-Blount, and Morley-Hennepin.

Soil Association Descriptions

Blount-Pewamo: Deep, very poorly drained to somewhat poorly drained, moderately fine textured and medium textured soils on till plains, moraines, and uplands.

Gessie-Shoals: Deep, nearly level, well drained and somewhat poorly drained, medium textured soils on floodplains.

Glynwood-Pewamo-Blount: Deep, gently sloping and nearly level, moderately well drained to very poorly drained, medium textured and moderately fine textured soils formed in silty material over glacial till and in glacial till on till plains and moraines.

Morley-Hennepin: Deep, gently sloping to very steep, moderately well drained and well drained, medium textured and moderately fine textured soils on uplands.

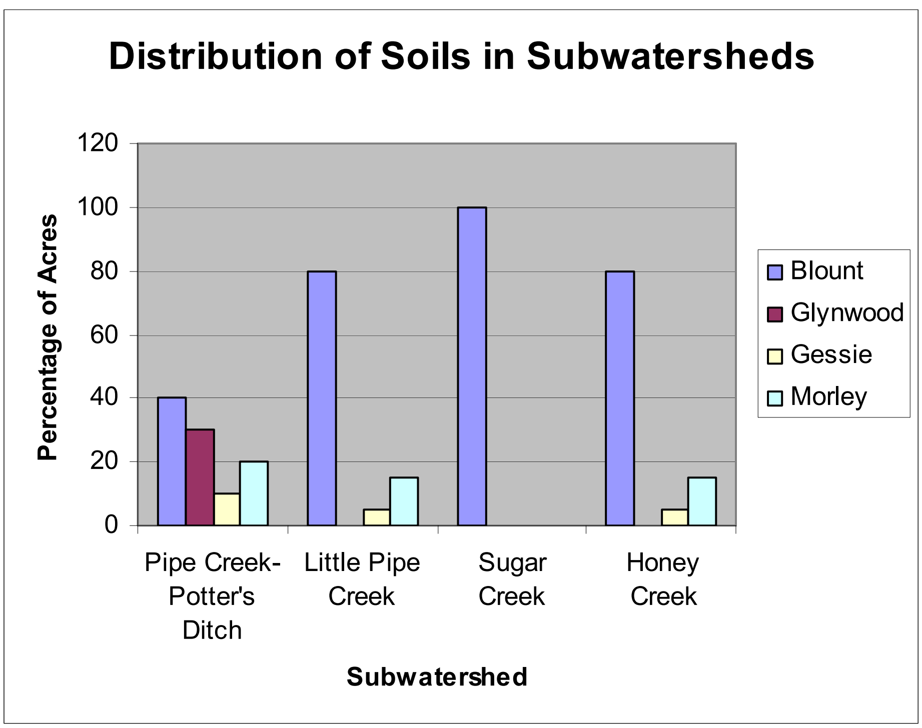

Figure 3. Distribution of Soils in Subwatersheds

HYDRIC SOILS

Approximately 46% (18,576 acres) of the total watershed is classified as having hydric soils. "Hydric soils are developed under conditions sufficiently wet to support the growth and regeneration of hydrophytic vegetation" (Natural Resources Conservation Service, Field Office Technical Guide II). The majority of hydric soils in these subwatersheds do not support hydrophytic vegetation due to the fact that their water tables have been altered by artificial subsurface drainage. This drainage has enabled most of the ground to be brought into agricultural production.

This watershed has the potential for some wetland restoration; but, it will likely be difficult to interest landowners since so much of the land is prime productive farmground. Where wetland restoration is recommended, it would likely have to be the improvement of existing wetlands or coordinated with financial assistance from state and federal conservation programs.

NITRATE LEACHING POTENTIAL

All of the major soils in the study area have a leaching index of 5 (NRCS, FOTG II), which is a medium potential for nitrate leaching. According to the NRCS FOTG II, a leaching index "between 2 and 10 may contribute to soluble nutrient leaching below the rootzone and nutrient management should be considered."

HIGHLY ERODIBLE LAND (HEL)

Highly Erodible Land (HEL) is a designation used for farmland/cropland to satisfy the regulatory aspects of the Food Security Act of 1985. In Indiana, ground can only be designated as HEL based on its "potential erodibility from sheet and rill erosion" (NRCS, Field Office Technical Guide, Section II (FOTG II)). Cropland is classified as HEL if its soil loss is equal to or greater than 8 tons/acre. Landusers should use special management practices, such as conservation tillage or cover crops (Appendix A) to keep these soils from eroding at non-sustainable rates.

Three percent (approximately 1,247.1 acres) of the entire watershed is designated as Highly Erodible Land (Figure 4). When comparing the four smaller subwatersheds, Pipe Creek-Potter Ditch has the highest percentage (8.7%) of HEL in its total acreage. HEL acres make up approximately 1% of the total acreages in both the Sugar Creek and Honey Creek subwatersheds. The Little Pipe Creek subwatershed has approximately 2% of its total acreage classified as HEL.

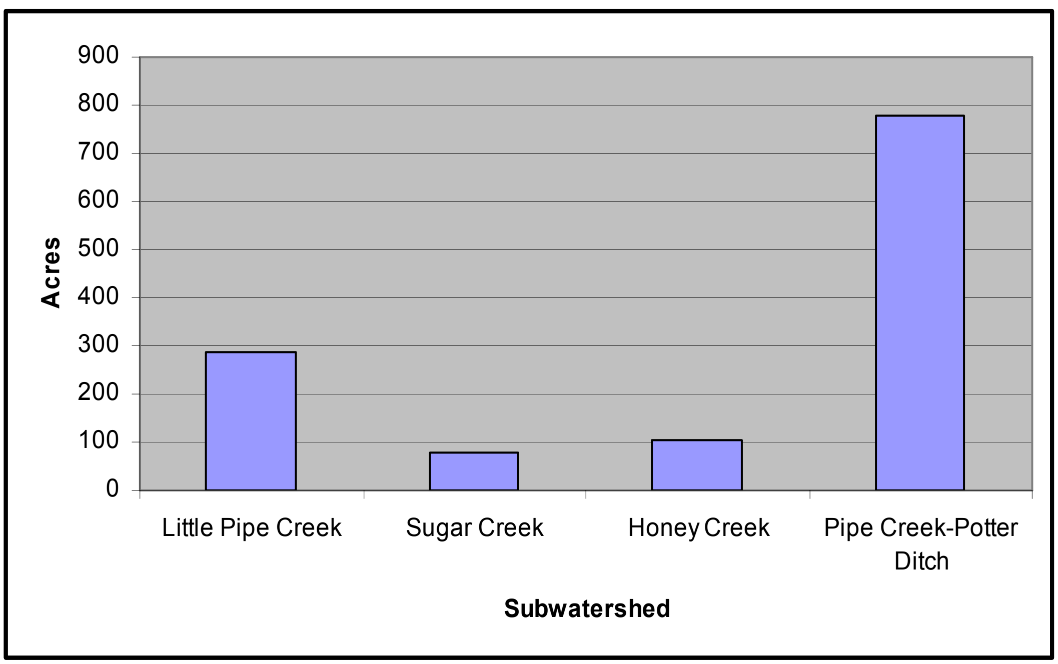

Figure 4. Highly Erodible Land (HEL) by Subwatershed

AGRICULTURE SUMMARY

Tables 5, 6, and 7 provide an agricultural summary based on each county's agriculture census. The number of farms in all three counties decreased between 1987 and 1997, while the size of operations and farms increased. Grant and Howard Counties have both seen a slight loss of cropland while Miami County saw a 0.2% increase in total cropland acres between 1987 and 1997. The notable decreases in livestock numbers in all three counties are most likely market related. According to Conservation Partnership Staff in Grant, Howard, and Miami counties, livestock prices bottomed out causing some producers to get completely out of the livestock business.

The other notable change is a large increase (163.6%) of irrigated land in Howard County. This is due to the fact that Howard County has seen a large increase in specialty crops, more specifically, tomatoes. According to Kerry Smith (District Conservationist, Natural Resources Conservation Service) the company Red Gold, Inc. has large contracts with farmers in Howard County to grow tomatoes. However, the producers growing tomatoes in Howard County are on the west side of the county, outside the boundaries of the subwatersheds in this study. There is one producer in Grant County that grows approximately 187 acres of tomatoes in the Pipe Creek-Potter's Ditch subwatershed. Tomato fields have an increased potential for more surface runoff due to conventional tillage practices and irrigation. Conventional tillage leaves little to no residue on the fields, which in turn reduces infiltration and increases surface water runoff.

TABLE 5
Grant County Agriculture Summary

Agricultural Highlight	1997	1992	1987	10-year change (%)
Farms (number)	575	630	744	-22.7%
Land in farms (acres)	192,292	196,537	196,132	-2.0%
Land in farms - average size of farm (acres)	334	312	264	26.5%
Total cropland (farms)	541	589	696	-22.3%
Total cropland (acres)	178,082	182,737	180,189	-1.2%
Total harvested cropland (farms)	486	562	674	-27.9%
Total harvested cropland (acres)	172,544	173,700	158,578	8.8%
Irrigated land (acres)	24	3	Withheld	
Market value of agriculture products sold ($1,000)	62,549	56,970	51,871	20.6%
Cattle and calves inventory (number)	4,728	6,000	7,395	-36.1%
Beef cows (number)	1,131	921	1,144	-1.1%
Milk cows (number)	982	1,008	1,160	-15.3%
Hogs and pigs inventory (number)	27,858	51,106	54,739	-49.1%
Sheep and lambs inventory (number)	390	492	888	-56.1%
Corn for grain or seed (bushels)	9,648,372	11,098,171	7,488,423	28.8%
Wheat for grain (bushels)	236,283	187,511	363,222	-34.9%
Oats for grain (bushels)	17,005	19,809	43,965	-61.3%
Soybeans for beans (bushels)	4,223,302	4,001,331	3,901,458	8.2%

(Source: GovernmentStats Counties, Commerce, & Agriculture, 2002)

TABLE 6
Howard County Agriculture Summary

Agricultural Highlight	1997	1992	1987	10-year change (%)
Farms (number)	486	566	677	-28.2%
Land in farms (acres)	147,750	148,609	153,607	-3.8%
Land in farms - average size of farm (acres)	304	263	227	33.9%
Total cropland (farms)	453	532	619	-26.8%
Total cropland (acres)	137,933	136,754	140,762	-2.0%
Total harvested cropland (farms)	436	510	595	-26.7%
Total harvested cropland (acres)	135,655	130,765	119,901	13.1%
Irrigated land (acres)	58	12	22	163.6%
Market value of agriculture products sold ($1,000)	62,587	56,428	47,705	31.2%
Cattle and calves inventory (number)	5,000	8,218	8,752	-42.9%
Beef cows (number)	792	1,735	1,264	-37.3%
Milk cows (number)	611	1,146	886	-31.0%
Hogs and pigs inventory (number)	73,259	95,148	80,254	-8.7%
Sheep and lambs inventory (number)	251	234	564	-55.5%
Corn for grain or seed (bushels)	9,159,882	9,760,009	7,411,497	23.6%
Wheat for grain (bushels)	180,442	126,968	160,422	12.5%
Oats for grain (bushels)	19,253	21,740	20,916	-8.0%
Soybeans for beans (bushels)	3,176,575	2,788,981	2,916,713	8.9%

(Source: GovernmentStats Counties, Commerce, & Agriculture, 2002)

TABLE 7
Miami County Agriculture Summary

Agricultural Highlight	1997	1992	1987	10-year change (%)
Farms (number)	678	771	818	-17.1%
Land in farms (acres)	197,198	188,843	196,019	0.6%
Land in farms - average size of farm (acres)	291	245	240	21.3%
Total cropland (farms)	639	718	775	-17.5%
Total cropland (acres)	175,108	169,587	174,677	0.2%
Total harvested cropland (farms)	588	678	749	-21.5%
Total harvested cropland (acres)	165,003	154,087	144,500	14.2%
Irrigated land (acres)	1,867	2,806	2,026	-7.8%
Market value of agriculture products sold ($1,000)	74,763	64,642	62,590	19.4%
Cattle and calves inventory (number)	14,578	15,322	20,657	-29.4%
Beef cows (number)	2,074	1,820	2,705	-23.3%
Milk cows (number)	2,547	2,855	3,716	-31.5%
Hogs and pigs inventory (number)	99,543	107,813	108,971	-8.7%
Sheep and lambs inventory (number)	808	784	1,337	-39.6%
Corn for grain or seed (bushels)	9,579,147	9,745,953	8,239,704	16.3%
Wheat for grain (bushels)	325,933	211,782	427,297	-23.7%
Oats for grain (bushels)	13,192	22,417	62,529	-78.9%
Soybeans for beans (bushels)	3,493,602	2,924,656	2,668,892	30.9%

(Source: GovernmentStats Counties, Commerce & Agriculture, 2002)

Conservation tillage practices have increased over the last ten years in all three counties for both corn and soybeans (Table 8). According to the NRCS Field Office Technical Guide, conservation tillage is any type of tillage that leaves at least 30% of the field covered by crop residue after planting. Mulch-till, no-till, ridge-till, and reduced till are all forms of conservation tillage. Crop residue helps to reduce soil erosion by decreasing surface water runoff and increasing infiltration. Increases in conservation tillage have come about due to advances in tillage, genetic, and herbicide technology and due to a lack of labor resources.

TABLE 8
Row Crop Tillage Systems by County
(In Percentages of Cropped Acres)

	Grant			**Howard**			**Miami**		
Tillage	Corn	Soybeans	Small Grains	Corn	Soybeans	Small Grains	Corn	Soybeans	Small Grains
	1990								
Conventional	98	85	4	98	97	0	92	98	0
Mulch-till	1	6	94	0	1	0	2	0	15
No-till	1	9	2	1	0	0	2	0	0
Ridge-till	0	0	0	0	1	0	4	2	0
Reduced-till	0	0	0	0	0	0	0	0	0
	1995								
Conventional	85	30	23	92	49	85	84	45	36
Mulch-till	2	8	0	3	18	10	6	12	8
No-till	13	62	77	5	33	5	10	43	52
Ridge-till	0	0	0	0	0	0	0	0	0
Reduced-till	0	0	0	0	0	0	0	0	0
	2000								
Conventional	52	15	0	38	14	0	56	11	82
Mulch-till	8	11	13	15	31	0	8	20	0
No-till	16	69	81	4	39	0	5	44	0
Ridge-till	0	0	0	0	0	0	0	1	0
Reduced-till	24	5	6	43	16	0	31	24	0

(Information source: Tillage Transect, Purdue University)

CROPS AND LIVESTOCK

Table 9 shows the total number of crops planted as well as the number of livestock for each county. There are several confined feeding operations in the watershed (Figure 5). All of the operations are regulated by IDEM due to their large numbers.

TABLE 9
Agricultural Statistics for Grant, Howard, and Miami Counties

	Grant County	Howard County	Miami County
Corn Planted (acres)	67,800	76,600	73,300
Soy Beans Planted (acres)	73,500	88,100	103,600
Winter Wheat Planted (acres)	3,400	5,100	4,900
Hay Harvested (acres)	2,600	5,400	3,200
Pig Crop	73,259	99,543	27,858
Cattle	4,900	11,000	4,000

Note: All statistics based on 1999 data, except for the pig crop numbers which are based on 1997 data and the cattle numbers which are based on 2001 data.

(Source: Indiana Agriculture Statistical Service, 2002)

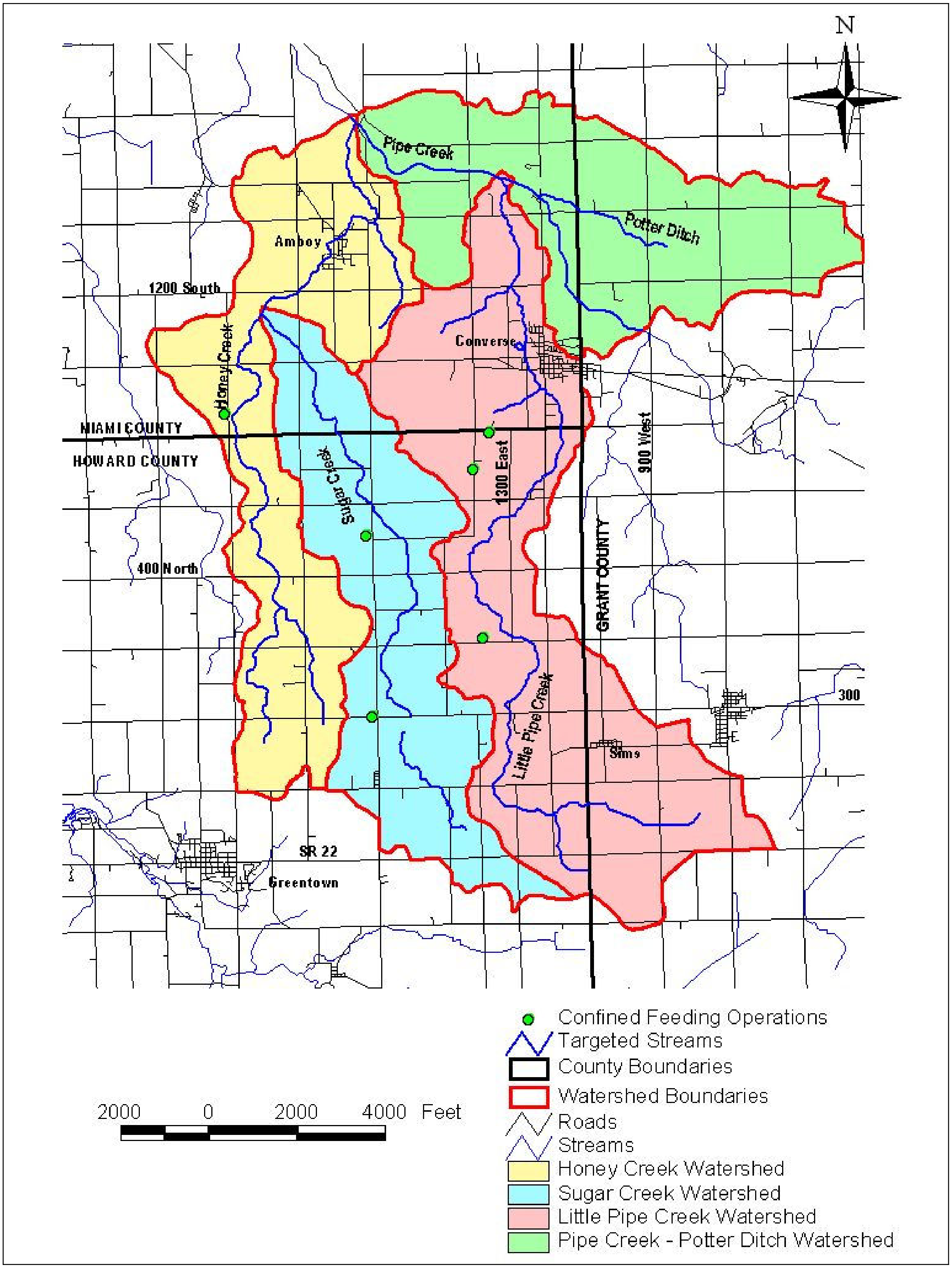

Figure 5. Confined Feeding Operations

SEPTIC SYSTEMS

Rural residences in these four subwatersheds have individual septic systems. There are three small towns located in the watershed- Amboy, Converse, and Sims. Currently, Amboy and Sims residents are still using individual septic systems. According to Alice Quinn at the Grant County Health Department, the residences in Sims are on small lots, have private wells, and lack adequate drainage. These conditions could lead to potential water quality problems as typical septic systems may not work to their full capability. Howard County residents within the boundaries of the subwatersheds are all on individual septic systems, according to Greg Lake at the Howard County Health Department. Converse has its own sewage treatment plant. According to Ken Scott of the Miami County Health Department, the town of Amboy is working on sending its sewage to the treatment plant at Converse. Currently, residents of Amboy have individual septic systems.

The soils in the watershed are not well suited for the average septic system (Table 10). According to the Grant County Soil Survey, soil limitations are considered "…severe if soil properties or site features are so unfavorable or so difficult to overcome that special design, significant increases in construction costs, and possibly increased maintenance are required" (page 57).

TABLE 10
Soil Characteristics for Septic Systems

Soil	Soil Limitation	Permeability (inches/hour)	Depth to Seasonal High Water Table	Depth to Bedrock	Susceptibility to Flooding
Blount-Pewamo	Severe	.06-2.00	1'-3'/+1-2'	>60"	none/ponding
Gessie-Shoals	Moderate/Severe	.06-2.00	>6'/0'-3'	>60"	rare/subject to flooding
Glynwood-Pewamo-Blount	Severe	.06-2.00	2.0'-3.5'	>60"	none
Morley-Hennepin	Severe	.06-2.00	3.0'-6.0' and greater/>4'	>60"	none

(Source: Deal, 1971; Deal 1979; Jensen, 1985)

PERMITTED DISCHARGERS

There is currently one National Pollutant Discharge Elimination System (NPDES) facility in the study watershed which is the Converse Wastewater Treatment Plant (Figure 6). The Wastewater Treatment Plant (WWTP) in Converse has a National Pollution Discharge Elimination System (NPDES) permit that allows the plant to discharge 250,000 gallons of treated wastewater into the Little Pipe Creek. The permit sets seasonal limits on levels of pollutants allowed in the wastewater (See Table 11 and Table 12). The Converse WWTP is currently working with the Indiana Department of Environmental Management (IDEM) to correct violations of the NPDES permit that occurred from March 1995 through May 1998. These violations included exceeding the permit limits for total suspended solids, biochemical oxygen demand, ammonia nitrogen, dissolved oxygen and total residual chlorine. According to Stacie Tucker from the IDEM Office of Enforcement, the WWTP is complying with an agreed order developed in 1999 between the two entities. Since this time, the WWTP has undergone changes that have made the plant more mechanical. It has also changed from chlorine disinfection to ultra violet disinfection, which has helped solve some of the violations.

According to Tucker, recent violations (2000 and 2001) have been related to rainfall events. Violations include overflows of 100 to 3,000 gallons of partially treated wastewater. According to plant superintendent Bud Cartwright, the plant's capacity will soon be increased to handle 300,000 gallons of wastewater per day. This will allow the town of Amboy to connect to the treatment plant and will handle future growth for the town of Converse.

Sources-
Cartwright, Bud. Personal interview. 13 Jan. 2003.
Tucker, Stacie. Personal interview. 15 Jan. 2003.

TABLE 11
Monthly Effluent Limitations for Converse Wastewater Treatment Plant

	Quantity or Loading			Quality or Concentration		
Parameter	Monthly Average	Weekly Average	Units	Monthly Average	Weekly Average	Units
Flow	Report	Report	MGD	-	-	-
$CBOD_5$						
Summer	31	48	lbs/day	15	23	mg/l
Winter	42	63	lbs/day	20	23	mg/l
TSS						
Summer	38	56	lbs/day	18	27	mg/l
Winter	50	75	lbs/day	24	36	mg/l
Ammonia-nitrogen						
Summer	3.1	4.8	lbs/day	1.5	2.3	mg/l
Winter	4.8	7.3	lbs/day	2.3	3.5	mg/l

(Source: State of Indiana, 2000)

TABLE 12
Daily Effluent Limitations for Converse Wastewater Treatment Plant

	Quality or Concentration			
Parameter	Daily minimum	Daily Maximum	Monthly Average	Units
pH	6	9	-	s.u.
Dissolved Oxygen-Summer	6	-	-	mg/l
E. coli□	-	235	125	count/100 ml

(Source: State of Indiana, 2000)

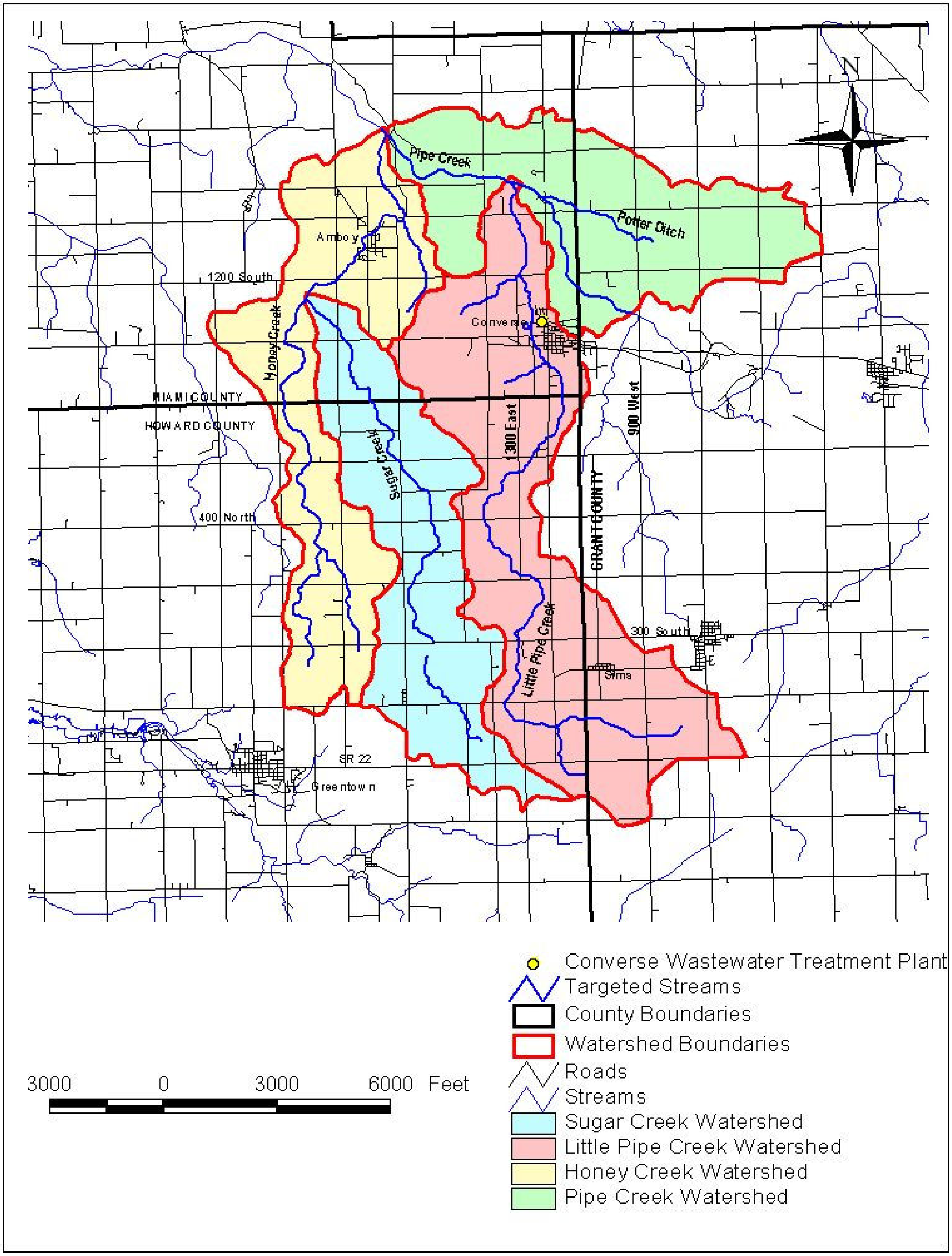

Figure 6. Permitted Dischargers

LAND USE

Table 13 and Figure 7 (GAPP map) provide a breakdown of the acreages in different landuses (over 96% of the ground is in cropland). There are approximately 9.5 acres of open water wetlands (such as ponds) in this watershed. Palustrine forested, palustrine herbaceous, and plautrine deciduous shrubland make up another 195.3 acres of wetlands.

TABLE 13
Land Use Data

Land Use	Area (acres)	Percent of Watershed
Agricultural: Pasture	466.2	1.163%
Agricultural: Row Crop	38,610.7	96.315%
Agricultural: Wet Areas	2.8	0.007%
Deciduous Forest	489.5	1.221%
Open Water	9.5	0.024%
Palustrine Forest	113.5	0.283%
Palustrine Herbaceous	60.0	0.150%
Plautrine Deciduous Shrubland	21.8	0.054%
Shrubland	30.1	.075%
Urban: High Density	73.2	0.183%
Urban: Low Density	210.6	0.525%
Woodland	0.10	0% (0.0002%)
Total	**40,088**	**100%**

(Source: USGS, 1992)

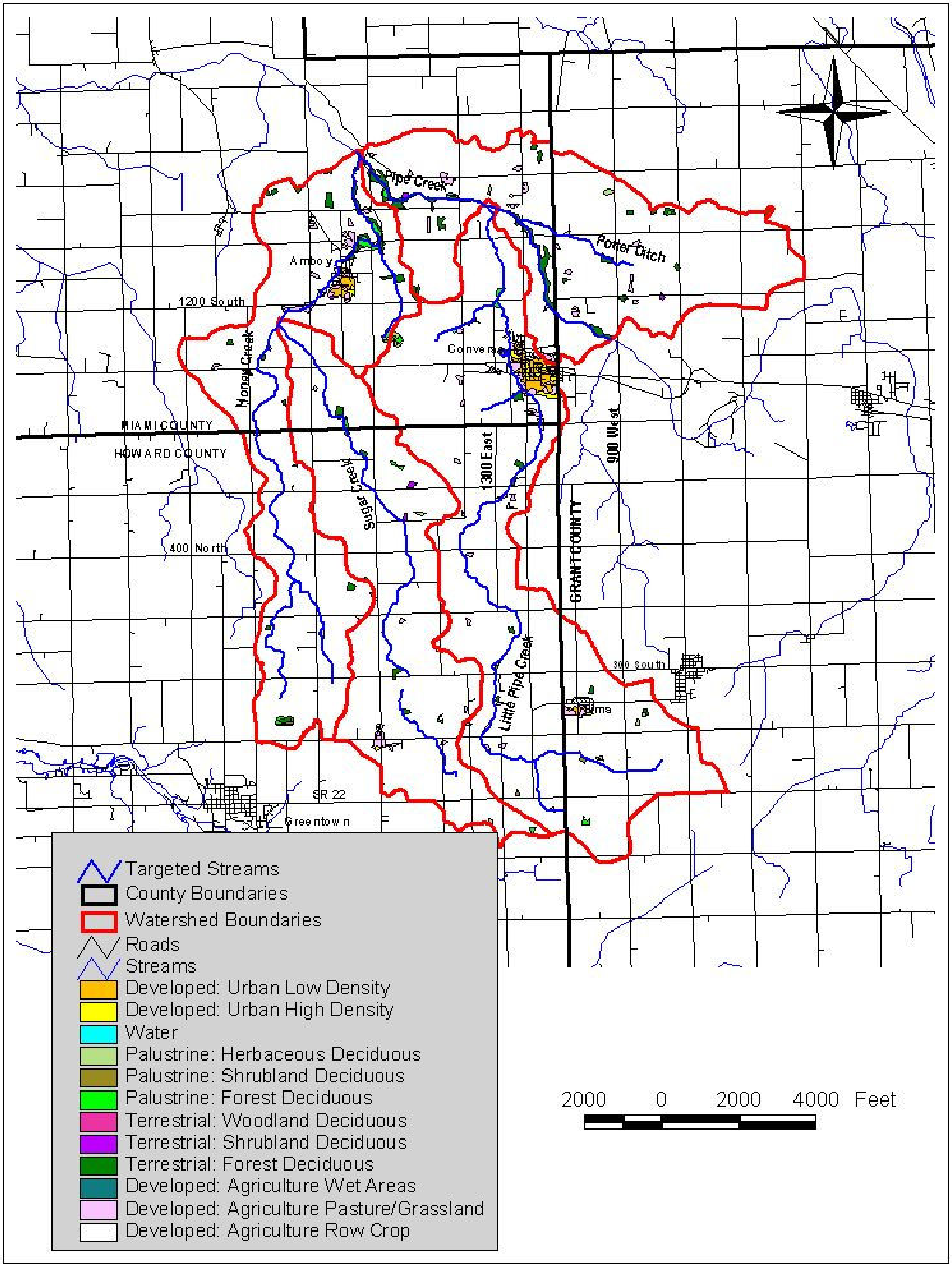

Figure 7. GAPP Land Use
(Source: USGS, 1992)

In order to complete a thorough watershed investigation, a windshield survey was completed on May 8, 2002. A windshield survey consists of driving on roads from one end of the watershed to the other in order to gain an understanding of current conditions (i.e. landuse, erosion, presence of buffers, etc.). Participants in this windshield survey were: Kelley Barkell, IDNR Resource Specialist; Sarah Garrison, Howard County Watershed Resource Technician; Gail Peas, IDNR Resource Specialist, and Jennifer Bratthauar, IDNR Agriculture Conservation Specialist. Two potential wetland enhancement sites were identified during the windshield survey. Both of these sites were located adjacent to Sugar Creek and were within two miles of each other (Appendix B). Even though some conservation practices have been installed in the subwatersheds, there is still a great deal of work to be done (Figure 8). Numerous filter strips have been established in some of the subwatersheds, but there are very few existing riparian buffers.

Damaging land use practices appeared to be kept to a minimum at the time of the windshield survey. Although most of the cropland lacked any type of residue, the majority of it is fairly level so sheet and rill erosion were not exceeding acceptable levels. When the ground became more rolling, some crop residue was left on the soil. However, the crop residue was not enough to prevent gully erosion in areas of concentrated surface runoff. Best Management Practices will have to be utilized in order to decrease gully erosion.

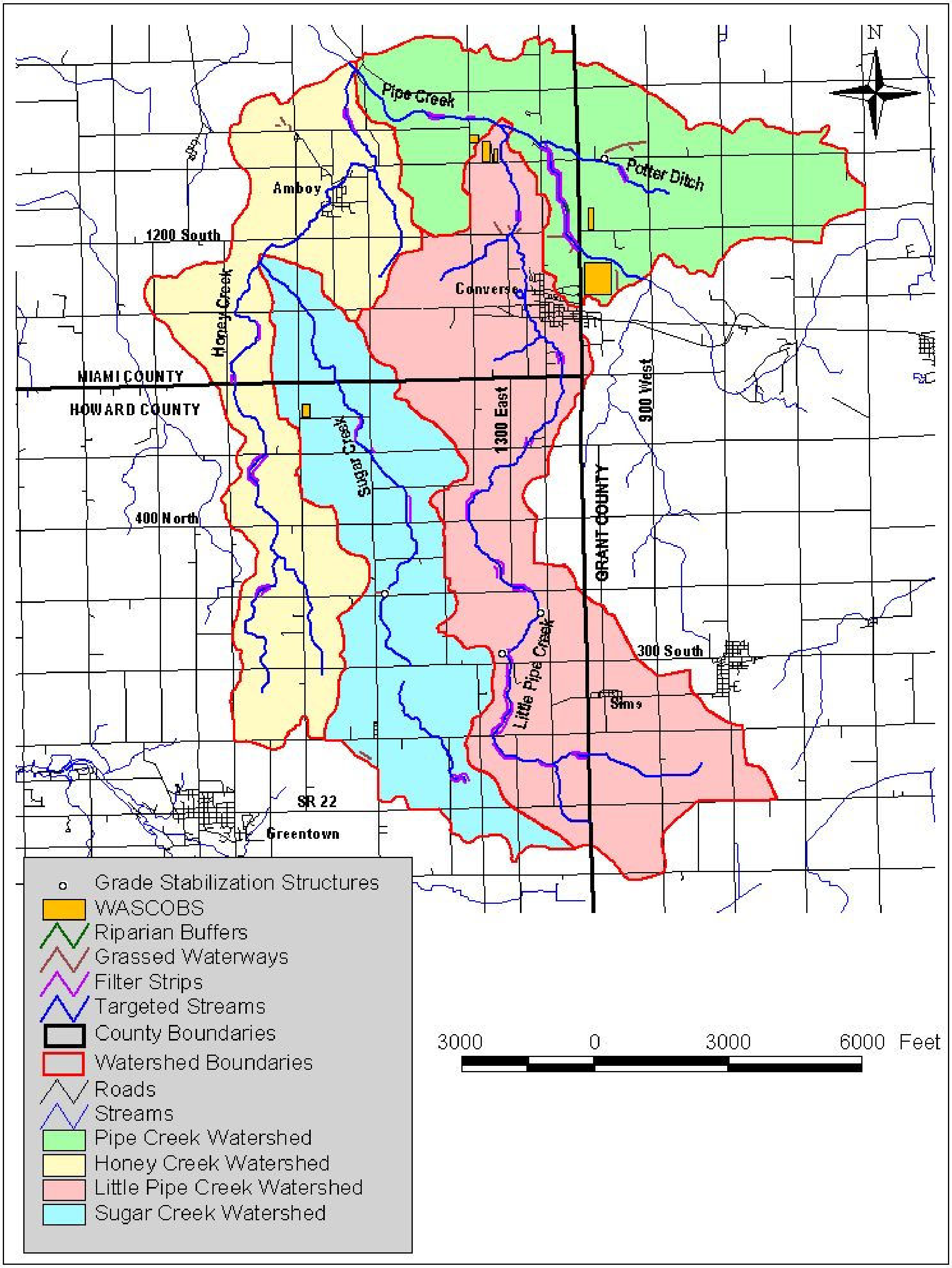

Figure 8. Existing Conservation Practices

LAND USE PLANNING

Currently, two of the three counties have existing planning documents. Grant County's planning documents have been in place since April of 1975 and their Comprehensive Plan was updated in October 2002. Miami County's Comprehensive Plan was approved by the Plan Commission and County Commissioners in 2001. A draft proposal of a Howard County Comprehensive Plan was voted down in early 2002. The county is currently looking for a new consultant to prepare another proposal.

Grant County Ordinances:
- Zoning Ordinance- updated in 2002
- Subdivision Ordinance- updated in March 2002
- Floodplain Ordinance- updated in 2002

Howard County Ordinances:
- Zoning Ordinance No. 1981-9 as amended
- Major Streets and Highways and Subdivision Control Ordinance 1977-38
- Flood Hazard Areas Ordinance No. 01994-53

Miami County Ordinances:
- Zoning Ordinance- updated in 2001
- Subdivision Control Ordinance- updated in 2001
- Floodplain Ordinance- updated once since 1996

SIGNIFICANT NATURAL AREAS AND ENDANGERED SPECIES

The four subwatersheds in this study are not listed as Natural and Scenic Rivers, Outstanding State Resource Waters, or Exceptional Use Streams. The creeks in these subwatersheds are tributaries to Pipe Creek, which makes its way into the Wabash River in Cass County. The Wabash River is listed as an Outstanding River in Miami County and numerous other counties, making it even more imperative that the contributing watersheds are improved and protected.

The Indiana Natural Heritage Data Center keeps comprehensive and up-to-date information on state and federal endangered, threatened, and rare species in Indiana. It also provides an up-to-date and comprehensive list of Indiana's high quality natural communities and significant natural areas.

A watershed map and request for endangered, threatened, and rare species information was sent to Mr. Ronald Hellmich at the Indiana Department of Natural Resources (IDNR) Division of Nature Preserves. There has only been one documentation (in 1902) of an endangered, threatened, and rare species in these subwatersheds. This species was the state endangered snake *Clonophis kirtlandii* (Kirtland's snake) which was documented in the Sims, Grant County area.

INSTITUTIONAL RESOURCES

The following pages list the existing institutional resources in Grant, Howard, and Miami Counties. The only volunteer water quality monitoring groups are local schools in Grant County which have taken some tests in the past on Potter's Ditch. There are no environmental groups, developers, or land managers for public properties based in any of the subwatersheds.

Soil and Water Conservation Districts (SWCDs), United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS), Indiana Department of Natural Resources Division of Soil Conservation (IDNR-DSC), and USDA Farm Services Agency (FSA)

Grant County SWCD, NRCS, IDNR-DSC, and FSA
1113 E. 4th Street
Marion, IN 46952
(765) 668-8983, ext. 3

Howard County SWCD, NRCS, IDNR-DSC, and FSA
1103 South Goyer Road
Kokomo, IN 46902
(765) 457-2114, ext. 3

Miami County SWCD, NRCS, IDNR-DSC, and FSA
1626 W. Logansport Rd.
Peru, IN 46970
(765) 473-6753, ext. 3

County Surveyors

Grant County Surveyor's Office
401 S. Adams St., Rm 322
Marion, IN 46953
(765) 668-8871

Howard County Surveyor's Office
Administration Center
222 N. Main Street
Kokomo, IN 46901
(765) 456-2217

Miami County Surveyor's Office
Miami County Courthouse
Peru, IN 46970
(765) 472-3901

County Commissioners

Grant County Commissioners
401 S. Adams St.
Marion, IN 46953
(765) 668-8871

Miami County Commissioners
Miami County Courthouse
Peru, IN 46970
(765) 472-3901

Howard County Commissioners
Administration Center
222 N. Main Street
Kokomo, IN 46901
(765) 456-2234

County Planning Commissions

Grant County Area Planning
401 S. Adams St., Rm 432
Marion, IN 46953
(765) 668-8871

Miami County Plan Commission
Miami County Courthouse
Peru, IN 46970
(765) 472-3901

Howard County Plan Commission
120 E. Mulberry Street
Kokomo, IN 46901
(765) 456-2330

County Health Departments

Grant County Health Department
401 S. Adams St.
Marion, IN 46953
(765) 668-8871

Miami County Health Department
Miami County Courthouse
Peru, IN 46970
(765) 472-3901

Howard County Health Department
120 E. Mulberry Street
Kokomo, IN 46901
(765) 456-2403

County Solid Waste Districts

Grant County Solid Waste District
401 S. Adams St., Rm 528
Marion, IN 46953
(765) 668-8871

Miami County Solid Waste District
25 Court Street
Peru, IN 46970
(765) 472-7224

Howard County Solid Waste District
120 E. Mulberry Street
Kokomo, IN 46901
(765) 456-2274

Purdue Cooperative Extension Offices

Purdue Cooperative Extension
401 S. Adams St., Rm 422
Marion, IN 46953
(765) 668-8871, ext. 413

Purdue Cooperative Extension
1029 W. 200 N.
Peru, IN 46970
(765) 472-1921

Purdue Cooperative Extension
120 E. Mulberry Street
Kokomo, IN 46901

IDNR Conservation Officers

IDNR Conservation Officer (Grant County)
3734 Mounds Rd.
Anderson, IN 46017
(765) 649-1062

IDNR Conservation Officer (Howard and Miami Counties)
1124 N. Mexico Rd.
Peru, IN 46970
(765) 473-9324

WATER QUALITY DATA

PREVIOUSLY EXISTING DATA

There is existing water quality data for this watershed, but it is somewhat incomplete and outdated. This data was included in spite of its incompleteness or date of sampling as a possible comparison to the water quality test results obtained from the professional consultant in this report.

Table 14 consists of data from the Hoosier Riverwatch Database. The numbers shown are an average of all the tests completed in that calendar year. Because Hoosier Riverwatch is primarily an educational program (students, teachers, and other volunteers conduct the tests), the results cannot be guaranteed to be accurate. In many cases, there were large discrepancies in the results that were used to obtain the averages, even when the same tests were conducted on the same day. Hoosier Riverwatch results were available for two of the tributaries: Little Pipe Creek and Potter Ditch.

Table 15 contains data from the year 1966 that was collected and compiled by the United States Environmental Protection Agency (USEPA). This sampling site was located on Pipe Creek approximately 7-8 miles downstream of the western most tributary, Honey Creek. These results were obtained far enough away from the tributaries that they don't offer any detailed or specific information about the targeted watershed.

TABLE 14
Hoosier Riverwatch Water Quality Results of Tributaries in Watershed

WATER BODY	Dissolved Oxygen (ppm)	Dissolved Oxygen (% Saturation)	pH	Total Phosphate (mg/L)	Nitrate NO3 (mg/L)	Turbidity (NTU)
Little Pipe Creek 2000	9.8	83.1	7.7	0.56	2.01	35.2
Little Pipe Creek 2001	8.4	78.8	7.46	0.74	137.9	40.23
Potter's Ditch 2001	8.34	79	5.95	0.65	13.1	16.5

(Source: Hoosier Riverwatch, 2002)

TABLE 15
1966 EPA Water Quality Results for Pipe Creek

Date of Sample	Time of Day	Dissolved Oxygen (mg/L)	Dissolved Oxygen (% Saturation)	pH	Total Phosphorous (mg/L as P)	Nitrate Nitrogen (mg/L as N)	Turbidity (Jackson Candle Units)
3/9/1966	4:30 PM	16.6	129.687	8	-	-	-
6/21/1966	11:20 AM	6.9	76.6889	7.1	0.26	2.35	65
6/23/1966	7:15 AM	6.3	68.4943	7.4	-	-	-
6/24/1966	10:35 AM	6.2	70.4753	7.7	-	-	25
8/22/1966	10:55 AM	6.8	75.5733	8	0.39	0.6	25
8/23/1966	7:30 AM	5.7	60.0148	8.1	-	-	-
8/24/1966	7:20 AM	5.6	54.9124	8.1	-	-	25
8/25/1966	1:30 PM	11.1	120.675	7.8	-	-	-
8/26/1966	7:10 AM	4.8	43.2496	7.9	-	-	25

(Source: STORET, 2003)

CURRENT WATER QUALITY CONDITIONS

A LARE Diagnostic Study requires testing and evaluation of set parameters to determine the water quality, biological quality, and habitat quality of the targeted waterbody. A total of 10 sites were tested, 9 sampling sites and one reference site (Figure 9). Sampling sites were selected with input from the Conservation Partnership Staff, Greg Bright of Commonwealth Biomonitoring, and Jill Hoffmann, IDNR Division of Soil Conservation Aquatic Biologist. The nine sites were chosen in order to obtain the best overall picture of what is happening throughout the watershed. All of the following information has been directly obtained from Greg R. Bright's (Commonwealth Biomonitoring) report "Rapid Bioassessment of the Pipe Creek Watershed Using Benthic Macroinvertebrates" (Appendix C).

Water quality was determined by sampling the following parameters: dissolved oxygen, pH, conductivity, temperature, chlorophyll A, turbidity, nitrate nitrogen, ammonia nitrogen, total phosphorus, orthophosphorus, and *E. coli*. Biological quality was determined by sampling and analyzing macroinvertebrate samples using EPA Rapid Bioassessment Protocol Level III. Habitat quality was assessed using Ohio EPA methods (Ohio EPA, 1987).

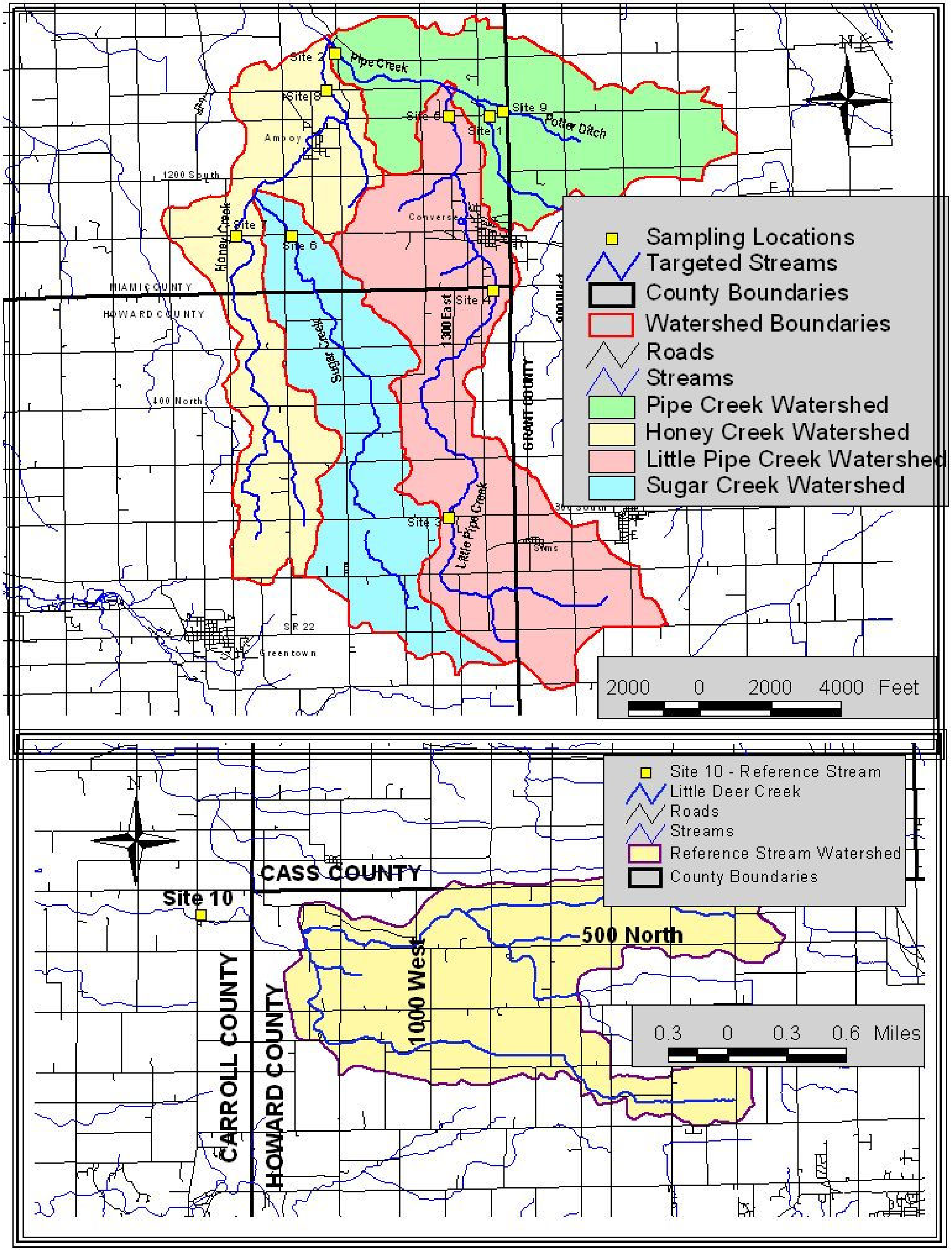

Figure 9. Water Quality Sampling Sites

Sampling Sites

Site 1	Pipe Creek at CR 1100 S
Site 2	Pipe Creek at CR 800 E
Site 3	Little Pipe Creek at CR 200 N
Site 4	Little Pipe Creek at 600 N
Site 5	Little Pipe Creek at CR 1100 S
Site 6	Sugar Creek at Hwy 18
Site 7	Honey Creek at Hwy 18
Site 8	Honey Creek at CR 1050 S
Site 9	Potter Ditch at CR 1100 S
Site 10	Little Deer Creek (ref. site)

Reference Site

The water quality and aquatic community of a reference site is compared to that of each study site to determine how much impact has occurred in the study watershed. The reference site should be in the same "ecoregion" as the study sites and be approximately the same size. It should be as pristine as possible, representing the best conditions possible for that area.

A recent study (Simon, 1998) found that Little Deer Creek had one of the best fish communities and habitat values in the area. Little Deer Creek has a drainage area which is similar to the study sites, is nearby, and is in the same ecoregion. Therefore, Little Deer Creek was used as the basis of comparison for all other sites in the study.

Water Chemistry Methods

Water chemistry measurements were made at each study site on the same day that macroinvertebrate samples were collected. Dissolved oxygen was measured by the membrane electrode method. The pH and temperature measurements were made with an Oakton pH/temp. probe. Conductivity was measured with a Hanna Instruments meter. All instruments were calibrated in the field prior to measurements.

Grab samples for nutrients and *E. coli* were collected and returned to the laboratory for analysis. Ammonia was measured by the selective ion probe method. Nitrate was measured by cadmium reduction and spectrophotometry at 530 nm. Phosphorus was measured by the ascorbic acid method and spectrophotometry at 660 nm. Chlorophyl and turbidity were measured by flourometry. *E. coli* were measured by membrane filtration, using m-coliblue as the media.

Habitat Analysis

Habitat analysis was conducted according to Ohio EPA methods (Ohio EPA, 1987). In this technique, various characteristics of a stream and its watershed are assigned numeric values. All assigned values are added together to obtain a "Qualitative Habitat Evaluation Index." The highest value possible with this habitat assessment technique is 100.

Macroinvertebrates

Sampling Methods

Because they are considered to be more sensitive to local conditions and respond relatively rapidly to environmental change (Hynes, 1970), benthic (bottom-dwelling) organisms were used to document the biological condition of each stream. The U.S. Environmental Protection Agency (EPA) has recently developed a "rapid bioassessment" protocol (Plafkin, 1989) which has been shown to produce highly reproducible results that accurately reflect changes in water quality. EPA's protocol III was used to conduct this study. Protocol III requires a standardized collection technique, a standardized subsampling technique, and identification of at least 100 animals from each site to the genus or species level from both study sites and a reference site. Coarse Particulate Organic Matter (CPOM) samples were collected and analyzed to determine the percentage of shredder organisms.

Sample Collection

Samples in this study were collected by kicknet from riffle habitat where current speed was 20-30 cm/sec. Riffles were used because they typically support the most diverse benthic community in streams. The kicknet was placed immediately downstream from the riffle while the sampler used a hand to dislodge all attached benthic organisms from rocks upstream from the net. The organisms were swept by the current into the kicknet and subsequently transferred to a white pan. Each sample was examined in the field to assure that at least 100 organisms were collected at each site. In addition, each site was sampled for organisms in CPOM by collecting leaf packs from fast-current areas. All samples were preserved in the field with 70% ethanol.

Laboratory Analysis

In the laboratory, a 100 organism subsample was prepared from each site by evenly distributing the whole samples in a white, gridded pan. Grids were randomly selected and all organisms within grids were removed until 100 organisms had been selected from the entire sample.

Each animal was identified to the lowest practical taxon (usually genus or species). As each new taxon was identified, a representative specimen was preserved as a voucher. All voucher specimens have been deposited in the Purdue University Department of Entomology collection.

WATER QUALITY SAMPLING RESULTS

All of the water quality testing for this portion of this study was completed by Greg R. Bright of Commonwealth Biomonitoring. The results and portions of the discussion shown here were obtained from his report "Rapid Bioassessment of the Pipe Creek Watershed Using Benthic Macroinvertebrates, October 2002" and "Rapid Bioassessment of the Pipe Creek Watershed Using Benthic Macroinvertebrates, April 2003".

Mussel Observations

Mussels were observed at several sites. The presence of mussels is a sign of relatively good water quality and habitat. The species that were present at the time of sampling are noted in Table 16.

Table 16
Mussel Observations

Sampling Site	Genus species	Status
10	Lampsilis siliquoidea	Live
10	Anodontoides ferussacianus	1 valve
10	Fusconala flava	1 valve
10	Toxolasma parvus	1 valve
1,2,10	Amblema plicata	live
8	Pyganodon grandis	2 valves

Water Quality (Chemistry) Measurements

Water samples were taken at each site for both a base flow event (October 8, 2002) and a storm flow event (April 1, 2003). Samples from base flow events represent average conditions in a stream. Chemistry measurements are taken from storm flow samples in order to get a better idea of the sediment and nutrients that are transported from the land with surface water runoff. Tests were completed for the following chemical parameters: dissolved oxygen (D.O.), pH, conductivity, temperature, chlorophyll A, turbidity, nitrite + nitrate (NO_3), ammonia (NH_3), total phosphorus (PO_4), orthophosphate (PO_4), and *E. coli.*

Base flow samples from each site indicate that most parameters fell within acceptable ranges for most forms of aquatic life (Table 17). Nutrient values were relatively low at all sites and none of the sites exceeded the Indiana water quality standard for *E. coli*. However, five of the sites (#3, #4, #5, #7, and #8) had higher than expected D.O., chlorophyll a, and turbidity levels. The presence of chlorophyll a is a direct result of algae production. As algae growth becomes more abundant, so does chlorophyll a. An overproduction of algae can cause large fluctuations in D.O. levels. There may be a sharp spike in D.O. levels (>10 mg/L) during the day when algae produce oxygen through photosynthesis. Typically, an excess of D.O. during the day is a very strong indication that there are large decreases in the D.O. levels (<5 mg/L) during the night. Algae cannot photosynthesize without sunlight, so they actually use dissolved oxygen during the night to go through the process of respiration. A great deal of oxygen is also used up in the process of decomposition. Higher algae growth eventually leads to a higher rate of decomposition.

TABLE 17

Water Quality (Chemistry) Measurements

10/8/2002- Base Flow

	Parameter										
Site	**D.O.** mg/l	**pH** SU	**Cond** uS	**Temp** C	**ChlA** ug/l	**Turb** NTU	**NO3** mg/l	**NH3** mg/l	**Total PO4** mg/l	**Ortho PO4** mg/l	**E. coli** /100 ml
Pipe Creek CR 1100 S (#1)	10.6	7.8	600	11.1	176	0.6	0.5	0.1	0.3	0.1	112
Pipe Creek CR 800 E (#2)	10.8	8.1	500	12.6	150	1.1	0.5	0.1	0.3	0.1	38
Little Pipe Creek CR 200 N (#3)	11.5	8.3	500	13.7	854	7.8	0.4	0.2	0.2	0.1	4
Little Pipe Creek CR County Line (#4)	11.1	8.2	500	12.6	650	6.0	0.5	0.2	0.1	0.1	87
Little Pipe Creek CR 1100 S (#5)	11.4	8.3	600	13.6	560	4.6	0.4	0.1	0.2	0.1	19
Sugar Creek Hwy 18 (#6)	10.8	7.9	500	14.8	142	1.1	0.4	0.1	0.3	0.2	122
Honey Creek Hwy 18 (#7)	12.1	9.0	500	16.8	1407	56.0	0.6	0.1	0.1	0.1	138
Honey Creek CR 1050 S (#8)	11.0	8.1	500	12.3	244	2.8	0.7	0.1	0.2	0.2	42
Potter Ditch CR 1050 E (#9)	10.3	7.7	500	10.7	17.5	2.1	0.44	0.1	0.12	0.10	187
Little Deer Creek (reference stream) Hwy 29 (#10)	10.8	7.8	500.0	11.0	181.0	5.7	1.0	0.2	0.1	0.1	120

D.O. = Dissolved Oxygen

Cond. = Conductivity

ChlA = Chlorophyll a

Turb. = Turbidity

NH3 = Ammonia (as Nitrogen)

NO3 = Nitrite + nitrate (as Nitrogen)

PO4 = Phosphate (as Phosphorus)

(Source: Bright, 2002)

Storm flow samples from each site indicate that D.O., pH, conductivity, and temperature all fell within acceptable ranges for most forms of aquatic life. *E. coli* levels exceeded the state standard of 235 colonies/100 mL at every site, including the reference stream. Tests were not done to determine whether the *E. coli* was from animal or human sources. However, due to the location of the sampling sites and information pertaining to the watersheds above those sites, it may be possible to draw some valid conclusions. For example, the high *E. coli* levels at site #4 may be due to human activity (i.e. failing septic systems) as there are no confined animal feeding operations upstream of that sampling point.

State surface water standards for turbidity were exceeded at every sampling site in the spring. The state standard for turbidity dictates that surface waters should have a value less than 50 NTU. The reference stream had an NTU value of 67. The only site that came close to the reference stream's value was site #7 on Honey Creek. The high turbidity values achieved during the storm event sampling indicate that large amounts of soil are being transported to the creeks from the surrounding watersheds.

Currently, there are no set standards for phosphorus (P) levels in Indiana surface waters. However, total P concentrations of 0.03 mg/L have been known to cause algal blooms. All of the total P levels in the storm samples exceeded this number.

Indiana does not have nitrate standards for warmwater habitat. However, the Ohio EPA has found that the median nitrate-nitrogen concentration in wadeable streams that supports modified warmwater habitat is 1.6 mg/L. Storm flow samples at all ten sites, including the reference stream, had NO_3 levels greater than or equal to 17.5 mg/L.

TABLE 18

Water Quality (Chemistry) Measurements

5/5/2003- Storm Flow

Site	Parameter										
	D.O. mg/l	**pH** SU	**Cond** uS	**Temp** C	**ChlA** ug/l	**Turb** NTU	**NO3** mg/l	**NH3** mg/l	**Total PO4** mg/l	**Ortho PO4** mg/l	**E. coli** /100 ml
Pipe Creek CR 1100 S (#1)	9.3	7.6	390	14	257	344	27.5	1.1	1.1	0.76	780
Pipe Creek CR 800 E (#2)	9.7	7.7	420	13	223	384	22.5	0.9	0.76	0.58	1120
Little Pipe Creek CR 200 N (#3)	9.8	7.5	420	14	196	210	32.5	1	0.44	0.35	660
Little Pipe Creek CR County Line (#4)	9.7	7.5	390	12.5	231	336	25	1.4	0.9	0.7	1320
Little Pipe Creek CR 1100 S (#5)	9.3	7.6	370	13	277	465	17.5	0.9	0.8	0.68	1060
Sugar Creek Hwy 18 (#6)	9.4	7.6	400	13.5	217	296	30	0.8	0.35	0.26	980
Honey Creek Hwy 18 (#7)	8.6	7.8	400	13.5	127	82	27.5	0.5	0.36	0.21	900
Honey Creek CR 1050 S (#8)	9.1	7.5	420	13	231	200	23.8	0.8	0.48	0.36	1140
Potter Ditch CR 1050 E (#9)	8.7	7.4	410	15	143	152	40	1	0.9	0.72	780
Little Deer Creek (reference stream) Hwy 29 (#10)	9.4	7.2	500	15	164	67	26.3	0.7	0.44	0.3	2180

D.O. = Dissolved Oxygen

Cond. = Conductivity

ChlA = Chlorophyll a

Turb. = Turbidity

NH3 = Ammonia (as Nitrogen)

NO3 = Nitrite + nitrate (as Nitrogen)

PO4 = Phosphate (as Phosphorus)

(Source: Bright, 2003)

Habitat Analysis Results

The maximum value obtainable by the QHEI scoring technique is 100, with higher values indicating better habitat. Sites with lower habitat values normally have lower biotic index values as well.

The scores indicate that the lowest habitat value in this study was at sites 3 and7 (most upstream sites on Little Pipe Creek and Honey Creek). Habitat at these sites was hampered by a paucity of stable bottom substrate and instream cover, by the lack of any riparian buffer zone, by intermittent flow, and by bank erosion. There was no flow at these sites prior to October 2002, and aquatic habitat was reduced to shallow, isolated pools for much of the summer.

A suitable value for warmwater habitat without use impairment is 60 or higher. Sites #3 and #7 fell well below this value. Other sites with significantly lower habitat values are #4, #5, and #6. Conditions that contributed to these lower habitat values are: lack of riparian buffers, no instream cover, and a lack of stable bottom substrate (i.e. small rocks, gravel, and natural debris such as logs).

TABLE 19
Aquatic Habitat Analysis

	QHEI	Area (Sq. mi.)	Substrate	Cover	Channel	Riparian	Pool/ Riffle	Gradient (% of)	QHEI Reference
Maximum value	100	15	15	15	15	15	15	10	
Site									
Pipe Creek CR 1100 S (#1)	73	11(72)	10	10	13	11	10	8	100
Pipe Creek CR 800 E (#2)	71	11(97)	10	9	13	10	12	6	99
Little Pipe Creek CR 200 N (#3)	36	6(5)	6	3	6	7	2	6	50
Little Pipe Creek County Line (#4)	50	8(12)	10	3	7	5	9	8	69
Little Pipe Creek CR 1100 S (#5)	46	9(21)	6	4	6	7	6	8	64
Sugar Creek Hwy 18 (#6)	48	8(13)	8	5	6	7	8	6	67
Honey Creek Hwy 18 (#7)	35	7(9)	2	6	6	8	0	6	49
Honey Creek CR 1050 S (#8)	70	9(27)	12	8	11	9	11	10	97
Potter Ditch CR 1050 E (#9)	56	5(3)	10	6	9	7	9	10	78
Little Deer Creek (reference stream) Hwy 29 (#10)	72	10(34)	12	9	12	9	14	6	100

*When the Ohio EPA habitat scoring technique was used, the aquatic habitat values listed above were obtained for each site in the study.

(Source: Bright, 2003)

Macroinvertebrate/Biotic Index Results

Macroinvertebrates were collected, preserved, and identified in order to calculate the Hilsenhoff Biotic Index. The Hilsenhoff Biotic Index (HBI) is used to assess low dissolved oxygen levels of surface waters caused by organic loading (Hilsenhoff 1977, 1982, 1987). However, the HBI may also be affected by thermal and chemical pollution, two more types of non-point source pollution (Hilsenhoff 1998, Hooper 1993).

Macroinvertebrates are used to calculate the HBI because: 1) they are easily collected, 2) relatively easy to identify, 3) they are common in essentially all streams, 4) are not very mobile, and 5) have life cycles up to a year or greater (Hilsenhoff 1977). Chemical tests may produce results that are over exaggerated depending on the amount of rainfall that has or has not occurred near the time of testing. Analyzing macroinvertebrates gives a better overall picture of a stream's health as they have to withstand the changes in rainfall events, weather, and man-made alterations. Each type of macroinvertebrate is assigned an organism tolerance value ranging from 0 to 10. The lower an organism's tolerance to decreased dissolved oxygen levels, the lower its BI value. A range of BI values for water quality classifications and degree of organic pollution was developed by Hilsenhoff (1977, 1982, 1987).

TABLE 20
Hilsenhoff Biotic Index
Water Quality Classifications

BI Value	Water Quality	Degree of Organic Pollution
0.00-3.50	Excellent	No apparent organic pollution
3.51-4.50	Very Good	Slight organic pollution
4.51-5.50	Good	Some organic pollution
5.51-6.50	Fair	Fairly significant organic pollution
6.51-7.50	Fairly Poor	Significant organic pollution
7.51-8.50	Poor	Very significant organic pollution
8.51-10.00	Very Poor	Severe organic pollution

(Source: Hilsenhoff, 1987)

A total of 57 macroinvertebrate genera were collected at the ten sites (Tables 21 and 22). The most commonly collected invertebrates were caddisfly larvae and riffle beetles. The pollution intolerant groups Ephemeroptera, Plecoptera, and Trichoptera (mayflies, stoneflies, and caddisflies) were abundant at all but two sites, but many of these were relatively tolerant net-spinning caddisflies. Truly intolerant forms were abundant at only three sites (the reference and sites 2 and 8). The number and type of macroinvertebrates that were collected and identified are shown in Table 21 and Table 22.

TABLE 21
Rapid Bioassessment Results
October 2002

Species	Site #1	Site #2	Site #3	Site #4	Site #5	Site #6	Site #7	Site #8	Site #9	Site #10
Chironomidae	5	5	17	4	6	1	8	19	29	1
Tipula	5	2	2	2	4	3	1	3	12	6
Stenonema	1	3								16
Stenacron				1	1			1	2	
Baetis		2						3		1
Heptagenia								1		
Isonychia								8		
Paracloedes										3
Cheumatopsyche	55	49	19	29	61			19	40	13
Hydropsyche	13	9	35	36	10	2		21	1	14
Ceratopsyche	1	7						13		16
Chimarra		1			8			1	1	9
Stenelmis	17	15	22	12	3	26	14	6	6	12
Optioservus				1		2				
Macronychus		1								
Dubiraphia			2			2				
Microcara									1	2
Berosus						12				3
Psephenus	1							1	2	2
Ischnura	1		1	1	1				1	1
Argia										1
Calopteryx				8	1	1			3	
Boyeria			1	3	3			1	1	
Sphaerium						1	1			
Corbicula	1	3								
Turbellaria			1	1	2	49	75			
Ferrissia		3					1	2		
Physella				1				1	1	
Orconectes				1						
Lirceus						1				
TOTAL	100	100	100	100	100	100	100	100	100	100

(Source: Bright, 2003)

TABLE 22
Rapid Bioassessment Results
May 2003

Species	Site #1	Site #2	Site #3	Site #4	Site #5	Site #6	Site #7	Site #8	Site #9	Site #10
Chironomidae	20	12	24	40	23	3	43	18	1	42
Tipula	12	2		6	3			2	3	
Simuliidae	4	1			1		2	2		4
Stenacron	8		2	14		1	2	2	3	
Stenonema		2						6	6	12
Caenis		57		3				16	4	12
Baetis								2		3
Plecoptera-Perlidae		3						1		
Cheumatopsyche	12	2	1	11	25			2	3	3
Chimarra										2
Stenelmis	28	4	14	26	36	49	44	32	38	13
Optioservus	1		3				2			
Microcara		1								
Berosus										1
Ischnura										1
Calopteryx		5								
Boyeria	15	4				4	1	3		
Sphaerium		3	34		4	12	1	6	8	1
Elimia			1							2
Turbellaria					1	1				
Ferrissia		4						6		
Physella			20		4	13	3		25	
Hirudinea			1					2	9	2
Orconectes					3		2			2
Oligochaeta						17				
TOTAL	100	100	100	100	100	100	100	100	100	100

(Source: Bright, 2003)

Macroinvertebrates were collected in both the spring and the fall. Using these 100 organism samples, each site was able to receive a Biotic Index score for both the spring and the fall. The Biotic Index scores are shown in Tables 23 and 24.

TABLE 23
Biotic Index Scores
October 2002

	Site									
	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10
Biotic Index	6.5	6.1	6.8	7.1	6.4	7.2	7.5	5.8	6.5	4.6
# of Genera	10	12	9	13	11	11	6	15	13	15
Scrapers/Filterers	0.3	0.3	0.4	0.2	0.1	8.7	15	0.2	0.3	0.6
EPT/Chironomids	14	16	3.1	17	13	5	0.1	3.7	1.5	72
% Dominant Taxon	55	49	35	36	61	49	75	21	40	16
EPT Index	4	6	2	3	4	1	0	8	4	7
Community Loss Index	0.6	0.5	1	0.7	0.7	0.9	2	0.4	0.4	0
% Shredders	5	2	2	2	4	3	1	3	12	6

(Source: Bright, 2002)

TABLE 24
Biotic Index Scores
April 2003

	Site									
	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10
Biotic Index	5.4	6.5	7.1	5.2	5.2	6.9	5.8	5.9	6.4	5.7
# of Genera	8	13	9	6	9	8	9	14	10	14
Scrapers/Filterers	2.3	1.5	1.2	3.6	1.3	5.3	17	4.6	6.5	3.1
EPT/Chironomids	1.2	5.3	0.1	0.7	1.1	0.3	0.1	1.6	16	0.7
% Dominant Taxon	28	57	34	26	36	49	44	32	38	20
EPT Index	2	4	2	3	1	1	1	5	4	5
Community Loss Index	1.3	0.5	0.9	1.7	0.9	1.4	1.1	0.4	0.7	0
% Shredders	8	59	2	17	0	1	4	26	13	25

(Source: Bright, 2003)

PHOSPHORUS MODELING

Over the years, standard modeling has been developed as a tool to determine the amount of nutrient loading into a waterbody from its surrounding watershed. In freshwater lakes, streams, and rivers, phosphorus is the limiting nutrient, meaning that an excess amount of this nutrient may cause algae blooms and an overabundance of aquatic plants. Because phosphorus has the ability to bind to soil particles, there is a direct correlation between landuse and phosphorus exports (Table 25). Therefore, a standard phosphorus model (Reckhow et al, 1980) was used to determine the amount of phosphorus loading that was occurring in each subwatershed.

TABLE 25
Phosphorus Export Coefficients (kg/hectare-year)

Estimate Range	Row Crops	Non-Row	Pasture	Forest	Urban
High	5.0	1.5	2.5	0.3	3.0
Mid	2.0	0.8	0.9	0.2	1.0
Low	1.0	0.5	0.1	0.1	0.5

None of the subwatersheds had a significant amount of conservation tillage in use. However, Honey Creek, Sugar Creek, and Little Pipe Creek consist of ground that is fairly flat in nature, making it less erosive. Therefore, row crops in these three subwatersheds were given a low range estimate of 1 kg/ha/yr as their phosphorus export coefficient. The ground in the Pipe Creek-Potter Ditch subwatershed is much more undulating, so row crops in this watershed were given a high range export coefficient of 3 kg/ha/yr. Urban landuses were given a coefficient of 1.0-1.9 kg/ha/yr due to the fact that even the higher density urban areas in this watershed are only small towns. Phosphorus loading was calculated for each subwatershed by multiplying the phosphorus export coefficient by the number of acres (converted into hectares) in each landuse (Table 26).

TABLE 26
Phosphorus Loading (kg/year)

Land Use	Subwatersheds			
	Little Pipe Creek	Sugar Creek	Honey Creek	Pipe Creek-Potter Ditch
Pasture	66.1	21.2	50.2	44.9
Row Crops	5,213.4	3,248.8	3,458.7	9,817.8
Urban: Low Density	58.2	0.0	26.4	0.0
Urban: High Density	60.3	10.1	10.1	0.0
Deciduous Forest	7.4	3.2	23.3	46.5
Palustrine Forest	4.2	4.2	5.3	1.1
Palustrine Herbaceous	2.1	2.1	2.1	1.1
Shrubland	0.0	1.1	0.0	0.0
Open Water	0.0	0.0	0.0	0.0
TOTAL	5,411.7	3,290.7	3,576.1	9,911.4

The subwatershed receiving the highest level of phosphorus loading is Pipe Creek-Potter Ditch. This subwatershed not only has the highest number of acres within its boundaries, but also has the highest number of acres identified as HEL (Highly Erodible Land). In order to reduce some of this phosphorus loading, the first priorities for the Pipe Creek-Potter Ditch subwatershed should be to decrease soil erosion and reduce nutrient inputs through the implementation of nutrient management practices on cropland.

PRIORITIZATION OF SUBWATERSHEDS

Based on the water quality results from the base flow (fall) and storm flow (spring) samples, it is apparent that every subwatershed involved in this study is slightly impaired from nutrients, sediment, or E. coli. Therefore, it was necessary to come up with some method of prioritizing the subwatersheds in order for the Soil and Water Conservation Districts to know where they should begin focusing their efforts.

In order to prioritize the subwatersheds, a ranking system was set up across each parameter. Since there were ten sampling sites, test results from each parameter could be assigned a number one through ten. The best case scenario within that parameter was given a number one, while the worst case scenario was given a number ten. After all the test results were ranked, the ranking numbers for the parameters at each sampling site were added to get a total water quality score. Most of the subwatersheds had more than one sampling site, so in order to maintain the integrity of the data, each site was scored individually. The results of this prioritization process are shown in Table 27 (fall data) and Table 28 (spring data).

According to this ranking process, the sites with the best water quality at base flow were #1 (Pipe Creek at CR 1100 S), #2 (Pipe Creek at CR 800 E), and #9 (Potter Ditch at CR 1050 E). The sites on Pipe Creek had aquatic habitats that were equal to or better than the aquatic habitat at the reference site. They also had the lowest turbidity levels out of all ten sites, including the reference stream. The Potter Ditch site had the best scores out of all ten sites for D.O., pH, and temperature.

Honey Creek (site #7 at Hwy 18) ranked 9th out of 10 for water quality in the fall. Site #7 ranked so poorly because at the time the water quality samples were taken this area of Honey Creek was almost stagnant. The non-flowing water led to a large algae bloom which in turn gave this site the worst ranking for ChlA (ten out of ten). Honey Creek also had the lowest biotic index and habitat values out of all ten sites. The two sampling sites on Little Pipe Creek (site #3 and #4) ranked 8th and 7th (respectively).

However, the samples taken during the storm flow event show a much different picture of water quality than the samples taken during base flow conditions. The sites that ranked the best in the fall had some of the poorest water quality in the spring. Sites #1 and #2 which had the best ranking in the fall ranked 7th and 8th (respectively) out of ten sites. This is most likely due to the fact that these sites had the second and third worst (respectively) turbidity levels out of the ten sites.

The two sampling sites on Little Pipe Creek maintained their poor water quality ranking in the spring storm flow samples. Instead of being ranked 7th and 8th as they were in the fall, water quality results from the spring storm flow samples caused them to become ranked as 9th and 10th. In the spring, these two sites saw a rise in E. coli levels, P levels, NO3, and NH3 levels. The turbidity levels at these two sites increased by at least 150% over the turbidity levels that were obtained in the fall.

TABLE 27
Prioritization of Subwatersheds
Based on October 2002 Test Results

Parameter	Pipe Creek CR 1100 S (#1)	Pipe Creek CR 800 E (#2)	Little Pipe Creek CR 200 N (#3)	Little Pipe Creek CR Cty Line (#4)	Little Pipe Creek CR 1100 S (#5)	Sugar Creek Hwy 18 (#6)	Honey Creek Hwy 18 (#7)	Honey Creek CR 1050 S (#8)	Potter Ditch CR 1050 E (#9)	Little Deer Creek (reference stream) Hwy 29 (#10)
D.O. mg/l	10.6	10.8	11.5	11.1	11.4	10.8	12.1	11	10.3	10.8
Ranking	2	3	7	5	6	3	8	4	1	3
pH SU	7.8	8.1	8.3	8.2	8.3	7.9	9	8.1	7.7	7.8
Ranking	2	4	6	5	6	3	7	4	1	2
Cond. uS	600	500	500	500	600	500	500	500	500	500
Ranking	2	1	1	1	2	1	1	1	1	1
Temp. C	11.1	12.6	13.7	12.6	13.6	14.8	16.8	12.3	10.7	11
Ranking	3	5	7	5	6	8	9	4	1	2
ChlA ug/l	176	150	854	650	560	142	1407	244	175	181
Ranking	4	2	9	8	7	1	10	6	3	5
Turb. NTU	0.6	1.1	7.8	6	4.6	1.1	56	2.8	2.1	5.7
Ranking	1	2	8	7	5	2	9	4	3	6
NO_3 mg/l	0.5	0.5	0.4	0.5	0.4	0.4	0.6	0.7	0.4	1
Ranking	2	2	1	2	1	1	3	4	1	5
NH_3 mg/l	0.1	0.1	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.2
Ranking	1	1	2	2	1	1	1	1	1	2
Total PO_4 mg/l	0.3	0.3	0.2	0.1	0.2	0.3	0.1	0.2	0.1	0.1
Ranking	3	3	2	1	2	3	1	2	1	1
Ortho PO_4 mg/l	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.2	0.1	0.1
Ranking	1	1	1	1	1	2	1	2	1	1
E. coli /100 ml	112	38	4	87	19	122	138	42	187	120
Ranking	6	3	1	5	2	8	9	4	10	7
Habitat Analysis	73	71	36	50	46	48	35	70	56	72
Ranking	1	3	9	6	8	7	10	4	5	2
Biotic Index	6.5	6.1	6.8	7.1	6.4	7.2	7.5	5.8	6.5	4.6
Ranking	5	3	6	7	4	8	9	2	5	1
Total Score	33	33	60	55	39	45	78	42	34	38

Site columns above are grouped under the spanning header **Site**.

TABLE 28
Prioritization of Subwatersheds
Based on May 2003 Test Results

Parameter	Site: Pipe Creek CR 1100 S (#1)	Pipe Creek CR 800 E (#2)	Little Pipe Creek CR 200 N (#3)	Little Pipe Creek CR Cty Line (#4)	Little Pipe Creek CR 1100 S (#5)	Sugar Creek Hwy 18 (#6)	Honey Creek Hwy 18 (#7)	Honey Creek CR 1050 S (#8)	Potter Ditch CR 1050 E (#9)	Little Deer Creek (reference stream) Hwy 29 (#10)
D.O. mg/l	9.3	9.7	9.8	9.7	9.3	9.4	8.6	9.1	8.7	9.4
Ranking	4	6	7	6	4	5	1	3	2	5
pH SU	7.6	7.7	7.5	7.5	7.6	7.6	7.8	7.5	7.4	7.2
Ranking	4	5	3	3	4	4	6	3	2	1
Cond. uS	390	420	420	390	370	400	400	420	410	500
Ranking	2	5	5	2	1	3	3	5	4	6
Temp. C	14	13	14	12.5	13	13.5	13.5	13	15	15
Ranking	4	2	4	1	2	3	3	2	5	5
ChlA ug/l	257	223	196	231	277	217	127	231	143	164
Ranking	8	6	4	7	9	5	1	7	2	3
Turb. NTU	344	384	210	336	465	296	82	200	152	67
Ranking	8	9	5	7	10	6	2	4	3	1
NO_3 mg/l	27.5	22.5	32.5	25	17.5	30	27.5	23.8	40	26.3
Ranking	6	2	8	4	1	7	6	3	9	5
NH_3 mg/l	1.1	0.9	1	1.4	0.9	0.8	0.5	0.8	1	0.7
Ranking	6	4	5	7	4	3	1	3	5	2
Total PO_4 mg/l	1.1	0.76	0.44	0.9	0.8	0.35	0.36	0.48	0.9	0.44
Ranking	8	5	3	7	6	1	2	4	7	3
Ortho PO_4 mg/l	0.76	0.58	0.35	0.7	0.68	0.26	0.21	0.36	0.72	0.3
Ranking	10	6	4	8	7	2	1	5	9	3
E. coli /100 ml	780	1120	660	1320	1060	980	900	1140	780	2180
Ranking	2	6	1	8	5	4	3	7	2	9
Habitat Analysis	73	71	36	50	46	48	35	70	56	72
Ranking	1	3	9	6	8	7	10	4	5	2
Biotic Index	5.4	6.5	7.1	5.2	5.2	6.9	5.8	5.9	6.4	5.7
Ranking	2	7	9	1	1	8	4	5	6	3
Total Score	65	66	68	67	62	58	43	55	61	48

RECOMMENDATIONS

1. Implement soil conserving Best Management Practices (BMPs) such as conservation tillage, grade stabilization structures, grassed waterways, and other structural practices to reduce sedimentation in all four subwatersheds.

2. Encourage landusers to implement appropriate nutrient management plans and filter strips to attempt to reduce the amount of phosphorus and nitrogen loading in all of the subwatersheds.

3. Improve the vegetative buffer zone along the stream corridors. Tree plantings along streams should be encouraged to improve aquatic habitat. (Greg Bright)

4. Encourage landusers to fence their livestock out of the streams while working with them to install livestock crossings and watering facilities.

5. Consider a bank stabilization program on some of the headwater streams. Use vegetative stabilization techniques rather than rip-rap whenever possible. (Greg Bright)

6. Seek out funding sources to assist landowners with the installation of BMPs (Appendix D).

7. Work with the County Health Departments to educate landowners about proper septic system care and maintenance.

8. Increase stakeholders' knowledge of the water quality issues and concerns in their watershed which will increase their willingness to install BMPs.

9. Work with the County Surveyors to discourage channelization of the streams. Minimizing channelization allows the streams to retain a natural channel that enhances aquatic habitat. (Greg Bright)

10. Focus initial efforts in the subwatersheds that need the most water quality improvements, such as Little Pipe Creek and downstream on Honey Creek.

11. Continue to encourage volunteer monitoring in the watershed. Such programs provide invaluable educational opportunities and give participants a sense of ownership in the water quality improvements observed over the years. (Greg Bright)

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